PATENT SPECIFICATION

DRAWINGS ATTACHED

1,180,296

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Date of Application and filing Complete Specification: 5 April, 1967.
No. 15677/67.
Application made in France (No. 57054) on 8 April, 1966.
Application made in France (No. 61739) on 16 May, 1966.
Application made in France (No. 64998) on 10 June, 1966.
Complete Specification Published: 4 Feb., 1970.

Index at acceptance: —F4 HD13

International Classification:—F 25 c 1/00

COMPLETE SPECIFICATION

Improvements in or relating to Freezing Method and Apparatus

We, SOCIETE ANONYME HEURTEY, a body corporate organised under the laws of the French Republic, of 30—32, rue Guersant, Paris, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it si to be performed, to be particularly described in and by the following statement:—

The present invention relates to methods of and an apparatus for freezing liquid products. It is concerned with freezing methods wherein the product to be frozen can be brought to a temperature of about −80°C (−112°F) by using carbon dioxide (CO_2) as a refrigerant.

According to the present invention there is provided a method for freezing liquid products, characterized in that carbon dioxide in the gaseous phase is injected into the lower portion of a vertically elongated vessel at a temperature of from −75°C to −80°C, and that the product to be frozen is atomized into the upper portion of said vessel whereby the carbon dioxide gas and the product will flow or tend to flow in counter-current relationship and the carbon dioxide gas will cause the product to freeze..

According to a preferred embodiment of the invention the flow rate of the cold gaseous stream i.e: the carbon dioxide through the vessel is adjusted in order to achieve and/or maintain desired conditions and thus regulate the cooling of the product.

According to another embodiment of the method of this invention uniformly sized droplets of the liquid to be treated are atomized into the vessel by injection after a preliminary measuring step.

The method according to this invention has many very important features with respect to hitherto known methods also based on the use of carbon dioxide gas as a refrigerant. Some of these valuable features are set for hereinafter.

The carbon dioxide is used only in its gaseous phase, whereby the formation of crystals thereof likely to be detrimental in the system is definitely avoided.

The carbon dioxide gas and the product to be frozen flow or tend to flow in counter-current relationship, with the twofold advantage of promoting heat transfer conditions and obtaining a relatively long freezing time which may be for example several minutes or more. This freezing time is controllable and permits of preserving the whole or part of the characteristics and principles of the treated products.

The height of the vertically elongated vessel and/or the rate of upward flow of the carbon dioxide gas therein may be so calculated that the product to be treated reaches a temperature approximating −80°C (−112° F) before attaining the lower portion of the vessel, so that the complete mass is compulsorily brought to this temperature.

The diameter of the granules of frozen product may be of the order of 2 millimeters (0.08″) and can easily be modified if required.

The use of granulators is dispensed with.

Using the method of the invention it is possible to obtain products at exactly the desired and suitable granulometry, without any objectionable fine particles therefore it is particularly advantageous when the frozen products are intended for a subsequent drying or lyophilization treatment.

Other features and advantages of this invention will appear as the following description proceeds with reference to the accompanying drawing illustrating diagrammatically by way of example various forms of embodiment of this invention. In the drawing:

Figure 1 is a synoptic illustration of a first form of embodiment of a deep-freezing unit according to this invention; and

Figures 2 and 3 are similar views of modified forms of embodiment of the same unit.

The unit illustrated in Figure 1 comprises a vertically elongated vessel 1 equipped at its lower portion with injectors 2 for supplying gaseous CO_2 at a temperature of about −75°C to −79°C (−102°F to −110°F) and under a pressure slightly in excess of the atmospheric value.

The product to be deep-frozen, for example fruit juice, is introduced into the vessel 1 at the upper portion thereof through atomizers 5.

The carbon dioxide gas flows upwards in the vessel 1 and cools the drops of liquid product to be treated, for example fruit juice, until they are deep-frozen at about −75°C to −79°C (−102°F to −110°F). During this upward flow the carbon dioxide gas retards the fall of the liquid drops, so that the freezing time can be as long as desired.

The carbon dioxide gas emerging from the vessel 1 is thus brought to a higher temperature which may be for example of the order or −30°C (−22°F). A recycling compressor 10 forces the used gas through ducts 7 and 9 into a bath 8 retaining the entrained liquid particles and introduces the purely gaseous flow into a drier 11 and a separator or cyclone 12. From the outlet of this separator or cyclone one fraction of the gas is compressed by another compressor 13 and forced through a heat transfer unit 14 in which it is liquefied and directed into a storage tank 15 under a pressure of about 285 psi and at a temperature of −20°C (−4°F). The thus liquefied CO_2 is allowed to expand through a pressure reducing device 3 disposed upstream of the injectors 2. This expansion bring at −79°C (−110°F) the cold units necessary for cooling to −75°C/−79°C (−102°F to −112°F) the CO_2 gas fraction recycled through duct 16 which is injected into the vessel 1 by means of the nozzles 4 opening into the aforesaid injectors 2.

The deep-frozen fruit-juice granules are extracted from the bottom of the vessel 1 through a lock-chamber 6.

It will be seen that the greater part of the CO_2 is recycled directly through the duct 16, the other CO_2 fraction delivered to the heat transfer unit 14 corresponding only to the quantity necessary for reducing to −75°C/−79°C the temperature of the CO_2 fed to the vessel 1.

The liquid product to be frozen is introduced into the upper portion of the vessel 1 in such a way that all the drops of product built up therein have similar diameters and remain separate from one another or, in other words, that they do not tend to agglomerate. Thereafore, it is necessary that a given drop "B" following a preceding one "A" moves outside the turbulent zone created by this drop "A". Under these conditions, both drops "A" and "B" are retarded substantially in the same manner by the forces resulting from the frictional viscous contact between the gas and the drops, so that they will both fall at the same speed; any coalescence is thus safely avoided. Besides, due to the possible lateral movements of the drops during their fall it is also necessary that the horizontal distance between any two adjacent drops be kept at a value sufficient to prevent these drops from contacting each other.

This twofold requirement may be met for example by utilizing a static distributor, dispenser or atomizer comprising the plurality of suitably spaced nozzles delivering the drops at the requisite rate. A rotary injection device may also be used wherein suitably spaced outlet orifices for the liquid are provided.

The rate of gaseous flow through the vessel 1 and/or the gas temperature at the vessel inlet may be adjusted in order to achieve and/or maintain the temperatures necessary for producing the desired freezing according to the time during which this freezing is to be maintained. This temperature may be adjusted by properly proportioning the quantity of directly recycled gas and the gas fraction used for cooling this quantity.

In order to regulate the temperature of the cold gas in the freezing vessel, a reheater may be inserted in the direct gas recirculation duct. The temperature of the gas flowing through the vessel 1 may be adjusted at will by properly modifying the action exerted by this reheater.

This disposal is objectionable however in that it requires the use of a reheater and therefore increases the power consumption.

A more advantageous arrangement consists in utilizing a vessel of which the outer wall without any heat insulation is in direct contact with the surrounding atmosphere and to which one fraction of the gas emerging from the tower is fed, the temperature of the gas recycled in the vessel 1 being adjusted by introducing gas taken from this auxiliary vessel into the recycling circuit.

In the form of embodiment illustrated in Figure 2 a vessel 18 without heat-insulation is disposed between the ducts 16 and 17, and adapted to be filled with gas through a valve 19, another valve 20 controlling the communication between this vessel 18 and the duct 16. It is clear that by properly controlling by means of this valve 20 the quantity of gas stored in vessel 18 it is possible to regulate at will the temperature of the gas fed into the vessel 1. To compensate the gas output thus injected a leak-gas venting valve 21 is provided.

In the form of embodiment illustrated in Figure 3, the gas emerging from the top of vessel 1 is cooled before being re-injected into this tower by using a liquefied gas output taken from a reservoir 22 and expanded in a pressure-reducing device 23. The gas constantly injected into the vessel 1 is vented to the outside through another leak-gas valve 24.

The recycled gas output is adjusted by means of a valve 25 and measured by means of a vacuummeter 26.

To modify the mean gas temperature a warm gas storage vessel 27 without heat-insulation is provided. The gas contained in this vessel is re-injected into the circuit by using a fan 28 and a valve 29.

The method of this invention may be carried out in various manners.

It may be of the continuous type, that is, wherein the liquid product to be frozen is fed continuously into the freezing vessel.

However, a batchwise procedure may also be used, wherein the liquid to be frozen is introduced into the freezing vessel until a suspension of this liquid which fills the vessel nearly completely is formed by the action of the stream of carbon dioxide, the lock chamber, 6, being closed.

The freezing process is then completed and by properly reducing the rate of flow of the carbon dioxide gas in the vessel the frozen product can be exhausted and the cycle resumed.

This batchwise process can be carried out without difficulty if the quantity of gas recycled within the freezing vessel is properly controlled.

The liquid product to be deep-frozen may be introduced in a discontinuous manner by using a measuring pump and a stop and regulating valve.

Another advantageous feature of this batchwise or discontinuous method is that the height of the deep-freezing vessel can be reduced.

Although the present invention has been described in conjunction with preferred embodiments, it its to be understood that modifications and variations may be resorted to without departing from the scope of the invention, as defined by the appended claims.

WHAT WE CLAIM IS:—

1. A method of freezing liquid products, characterized in that carbon dioxide in the gaseous phase is injected into the lower portion of a vertically elongated vessel at a temperature of from —75°C to —80°C, and that the product to be frozen is atomized into the upper portion of said vessel, whereby the carbon dioxide gas and the product will flow or tend to flow in counter-current relationship and the carbon dioxide gas will cause the product to freeze.

2. A method according to claim 1, characterized in that uniformly sized droplets of the liquid to be treated are atomized into the vessel by injection after a preliminary measuring step.

3. A method according to claim 1, characterized in that the flow rate of the cold gaseous stream through the vessel is adjusted in order to regulate the cooling of the product.

4. A method according to claim 1, characterized in that the temperature of the gaseous stream within said vessel is varied according to the nature of the product to be frozen.

5. A method according to claim 1, characterized in that the process is carried out batchwise by introducing the product to be frozen into the vessel so that the gaseous stream converts it into a suspension filling substantially said vessel, the freezing process being subsequently completed, and the frozen product discharged, whereafter the cycle is repeated.

6. A method according to claim 5, characterized in that the quantity of gas introduced into said vessel is adjusted to allow evacuation of the product in suspension.

7. A method according to claim 1, characterized in that the gas used in the freezing treatment is recycled.

8. Apparatus for carrying out the method according to claim 1, characterized in that it comprises a vertically-elongated vessel provided at its lower portion with injectors for introducing the gaseous carbon dioxide at a pressure slightly greater than the atmospheric pressure, and a lock chamber for discharging the frozen product, and at its upper portion with atomizers for forming drops of the product to be frozen.

9. Apparatus according to claim 8, characterized in that it also comprises a circulation compressor located at the top of said vessel to direct the gaseous CO_2 which has passed through the vessel respectively through a liquid-filled vessel, a drier, a cyclone, and means for dividing the gaseous CO_2 into two fractions, a compressor forcing one fraction into a heat transfer unit to liquify it and direct it into pressure reducing devices disposed upstream of said injectors, nozzles means being disposed in said injectors downstream of said pressure reducing devices, to inject the other fraction into the vertically elongated vessel.

10. Apparatus according to claim 8, characterized in that the atomizers provided at the top of said tower deliver the product in the form of drops spaced from one another to prevent said drops from coalescing with one another.

11. Apparatus according to claim 8, provided with gas recycling means, characterized in that it comprises an auxiliary vessel of

which the external wall is not heat-insulated and is kept in contact with the atmosphere, said auxiliary vessel being supplied with carbon dioxide gas from said tower, the temperature of the gas recycled in said tower being adjusted by introducing into the recycling circuit gas from said auxiliary vessel.

12. Method substantially as described hereinabove with reference to the accompanying drawings.

13. Apparatus subustantially as described hereinabove and illustrated in the accompanying drawings.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1970.
Published by the Patent Office, 25, Southampton Buildings, London W.C.2, from which copies may be obtained.

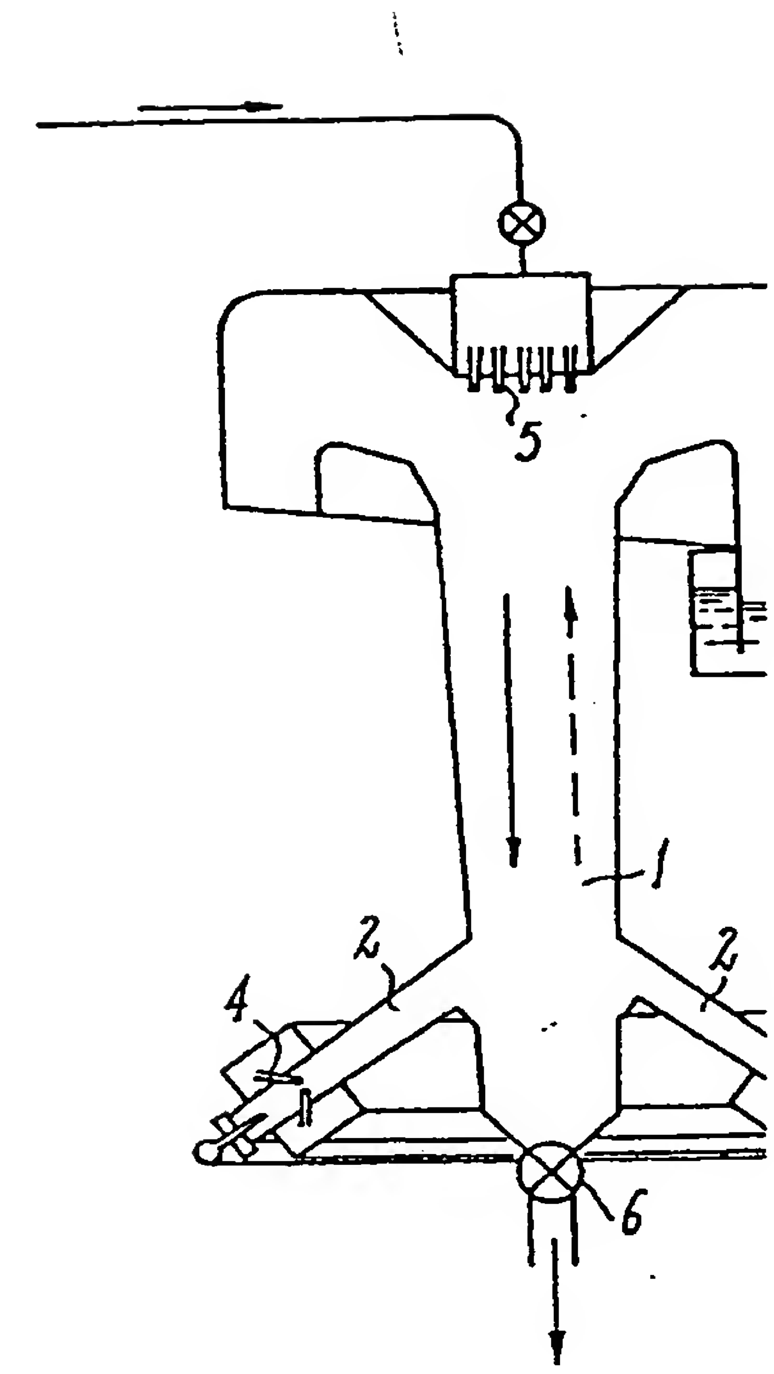
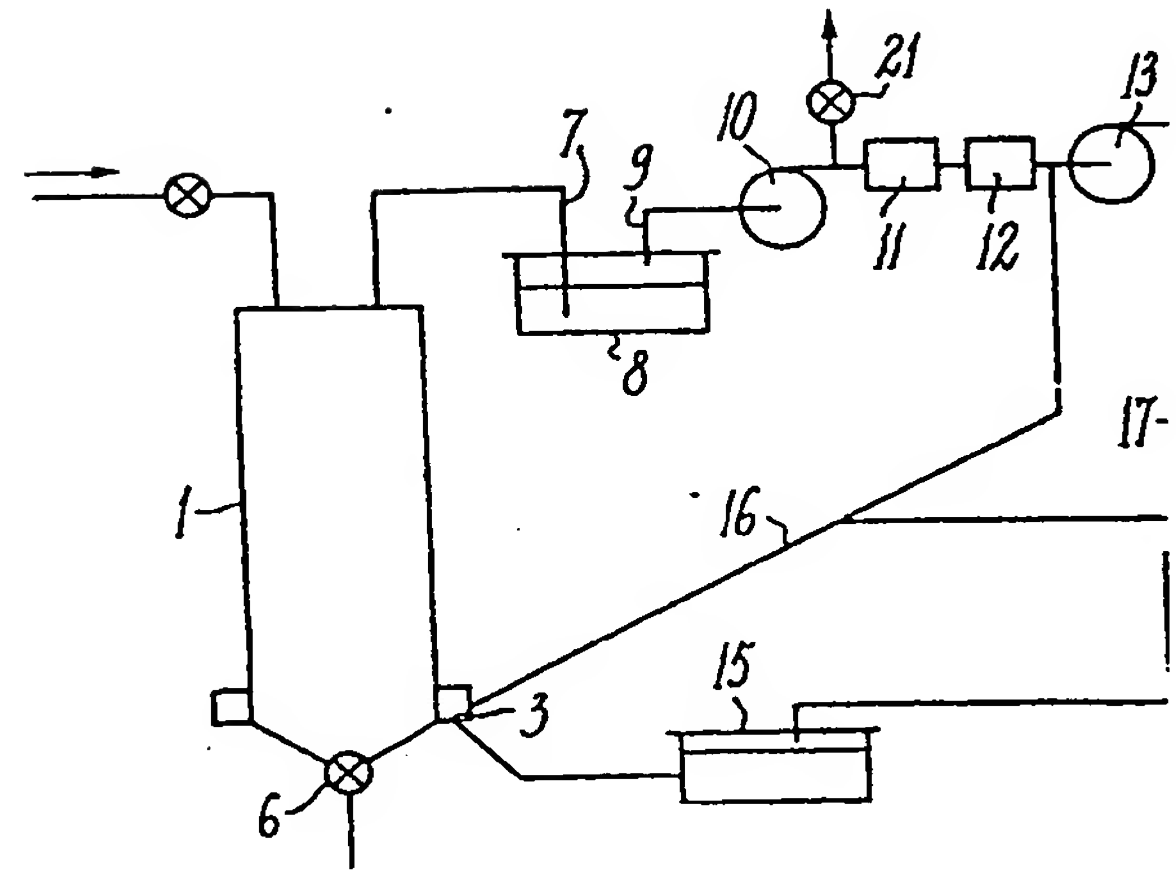


FIG. 2



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1 SHEET

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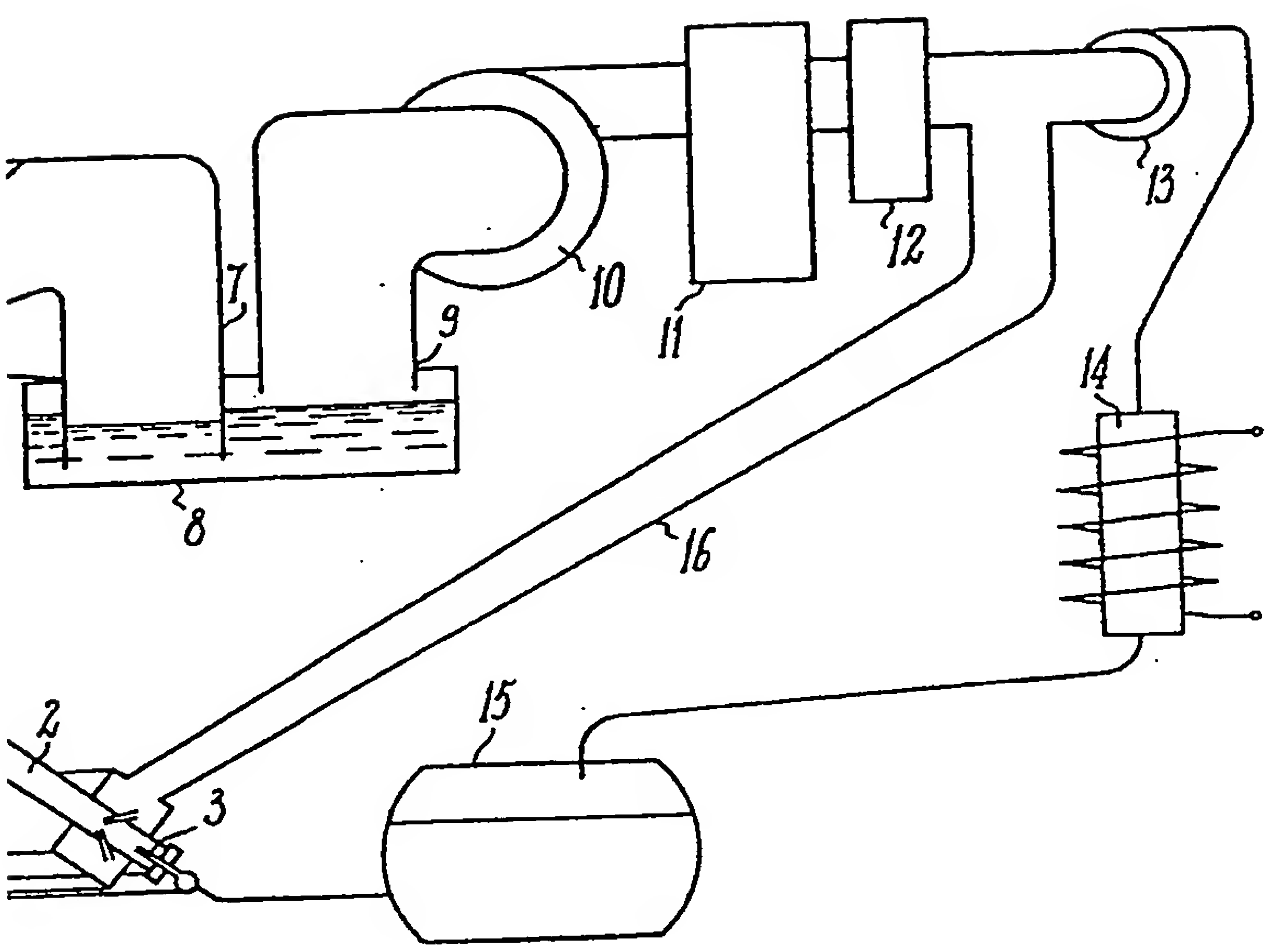
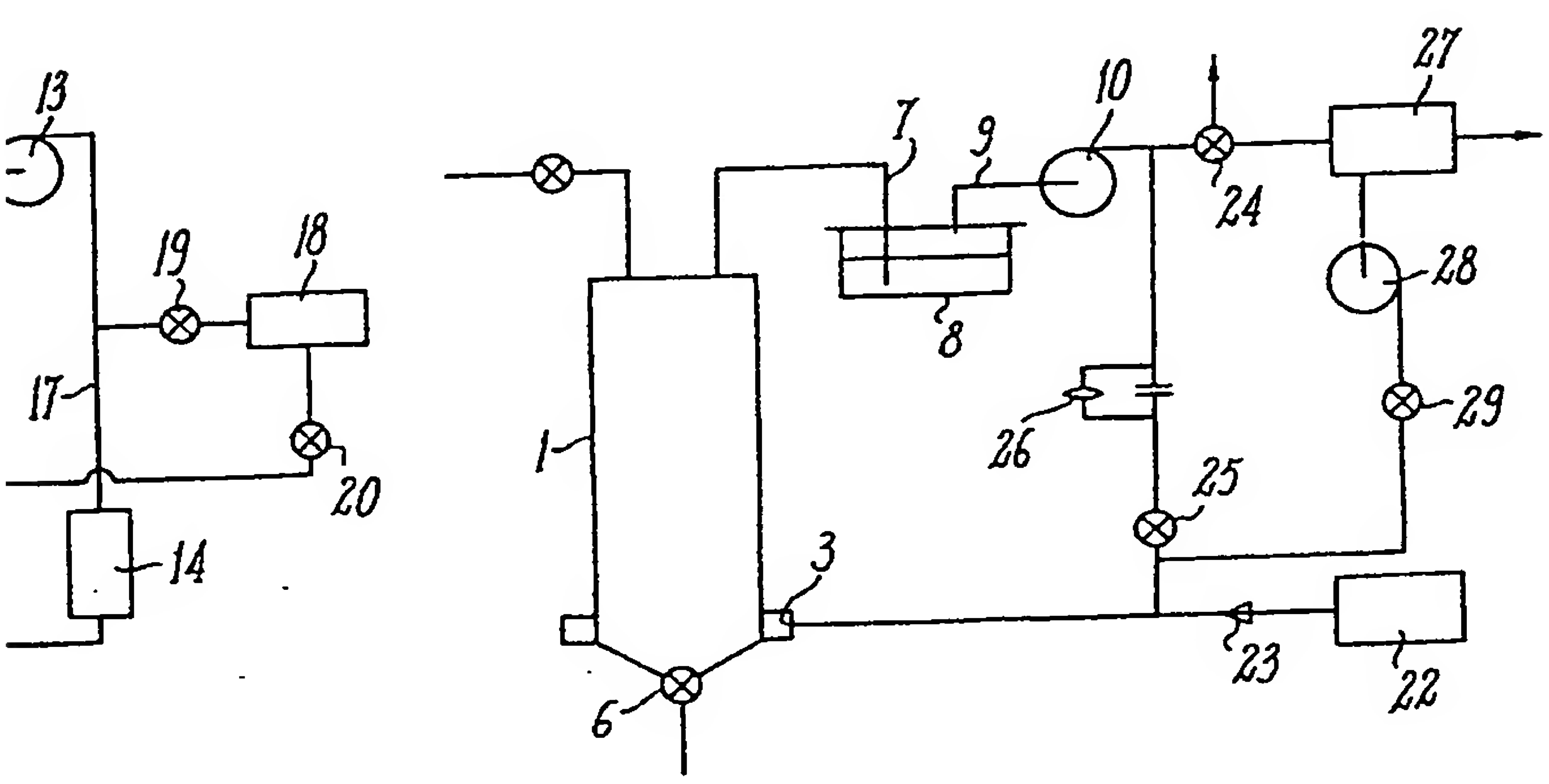


FIG. 1

FIG. 3



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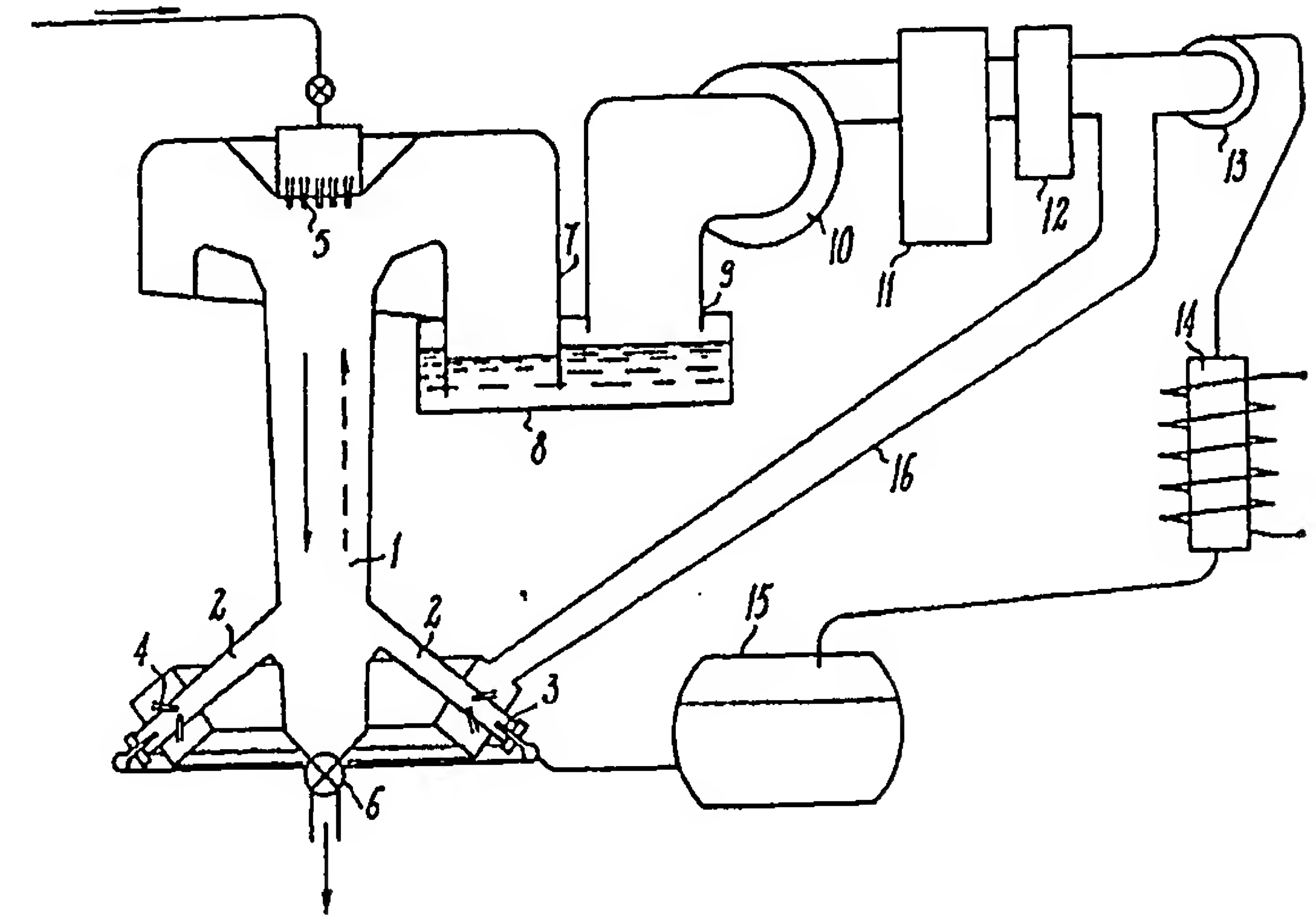

Fig. 1

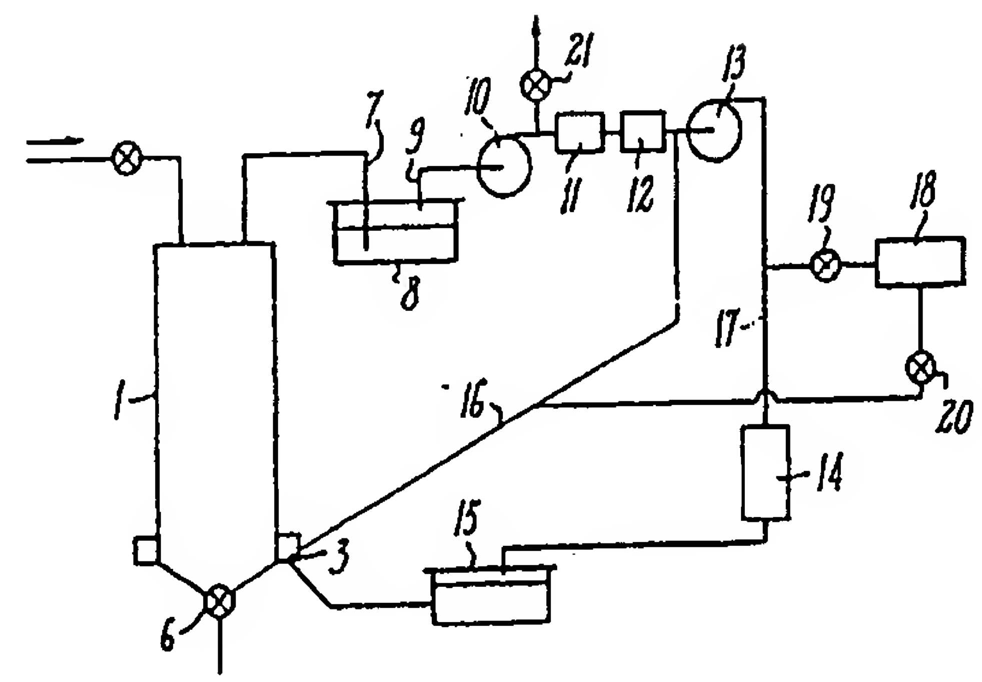

Fig. 2

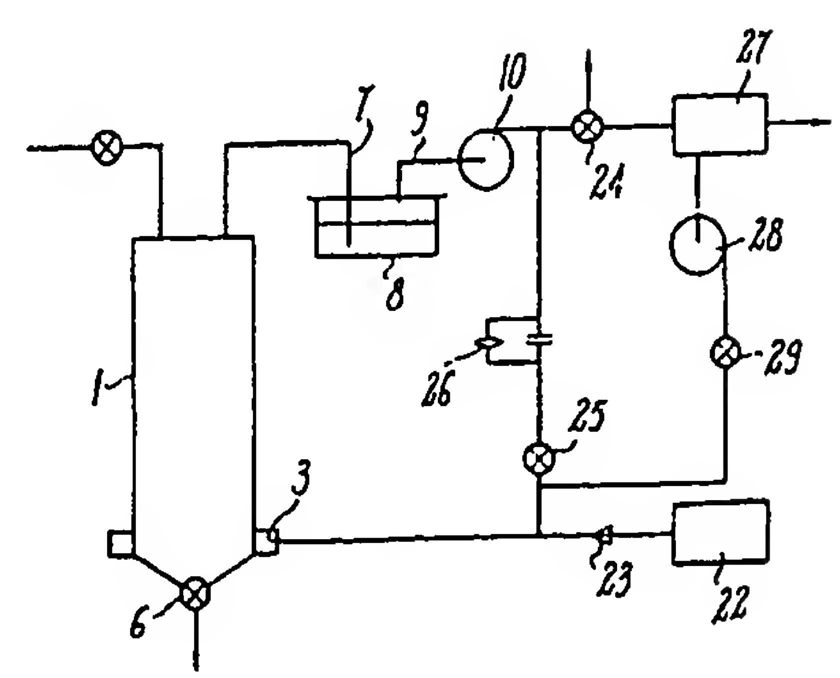

Fig. 3